UTC Aerospace Systems

Future Aircraft Engine Control Challenges

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ASME International Gas Turbine Institute Turbo Expo 2013
Controls, Diagnostics and Instrumentation Panel

AGENDA

UTPAS Perspective on Engine Control Challenges

What is UTPAS?

Future challenges:

- Complexity
- Packaging
- Operating environment

UNITED TECHNOLOGIES REORGANIZATION

Formation of UTC Propulsion & Aerospace Systems

Hamilton Sundstrand
A United Technologies Company

+

GOODRICH

=

UTC Aerospace Systems

+

PRATT & WHITNEY
DEPENDABLE ENGINES

=

United Technologies
Propulsion | Aerospace Systems

July 2012 – United Technologies formed UTC Aerospace Systems

TWO UTAS DIVISIONS

Aircraft Systems / Power Control & Sensing Systems

Actuation Systems
Primary & secondary flight controls
Helicopter rotor actuation
Nacelle actuation
Utility actuation

Interiors
Cargo handling systems
Evacuation systems
Propulsion systems
Specialty seating
Lighting systems

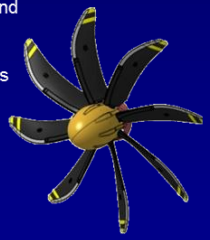
Wheels & Brakes
Wheels
Brakes
Brake control systems
High temp composites

Aerostructures
Nacelle systems
Flight control surfaces
APU tailcones
Acoustic materials, coatings & structures

Landing Gear
Landing gear – large commercial, military, regional & business jets

Air Management Systems
Environmental control systems
Bleed air systems
Cabin pressure systems
Ventilation systems
On board inert gas generating systems

Propeller Systems
Propeller systems with composite blades & electronic controls for regional aircraft and large military transports



ISR Systems
Reconnaissance systems
Airborne laser warning
Ground systems

Electric Systems
Generation
Primary distribution
Secondary distribution
Emergency power, Motors & Drives

Fire Protection Systems
Aircraft cargo, engine and APU fire detection/suppression
Cabin and lavatory fire protection systems
Armored combat vehicle fire sensing and suppression systems

Engine Components
Aero gas turbine components
Airfoils & rotating components
Drive shafts & couplings

Engine & Control Systems
Electronic engine controls
Engine control systems
Engine & nozzle actuation
Gearboxes
Fuel metering units
Fuel pumps

Sensors & Integrated Systems
Control & actuation systems
Temperature sensors
Vehicle health mgmt systems
Fire protection systems
Fuel measurement
Ice detection
Rate gyros & inertial sensors

Space Systems
NASA's space suit/life support systems
Environmental monitoring & control, mechanical systems, thermal control systems

ENGINE CONTROL SYSTEM CHALLENGES

Rapidly Changing Engine Design Space

- More complex systems to control
  - Increasing integration with airframe → UTPAS
  - New variable geometry in engine
- Increasing control system sophistication
  - Model-based controls
  - On-board engine health management
- Packaging
  - Smaller engine cores w/ larger or no fans
  - Decreasing real estate available for components
- Harsher environments
  - Increasing temperatures / thermal cycling
  - Vibration

APPROACH TO MANAGING COMPLEXITY

More-Electric Engine Architectures

Failure modes

Loss of power, single-point/multi-point failures, software

Unintended interactions

Engine / generator

Power generation

Weight, reliability

Power distribution

Weight, reliability

EMI/HIRF/Lightning susceptibility

Software validation (DO-178C)

APPROACH TO MANAGING COMPLEXITY

Increased Controls Integration

Failure modes

Loss of power, single-point/multi-point failures, software

Unintended interactions

Latency, data integrity, aircraft control

Increased connections

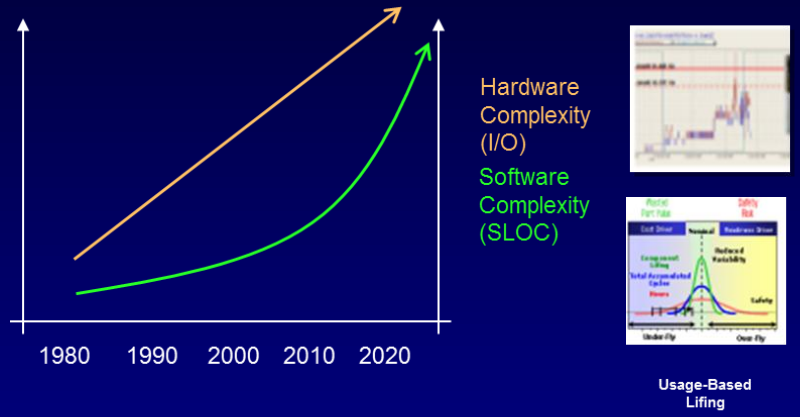
Reliability

Communications protocol(s)

Multiple protocols in play

EMI/HIRF/Lightning susceptibility

Software validation (DO-178C)



APPROACH TO PACKAGING CONCERNS

Distributed Architectures

Failure modes

Loss of power, single-point/multi-point failures, software

Unintended interactions

Latency, data integrity

Increased connections

Reliability

Potential harsher environment

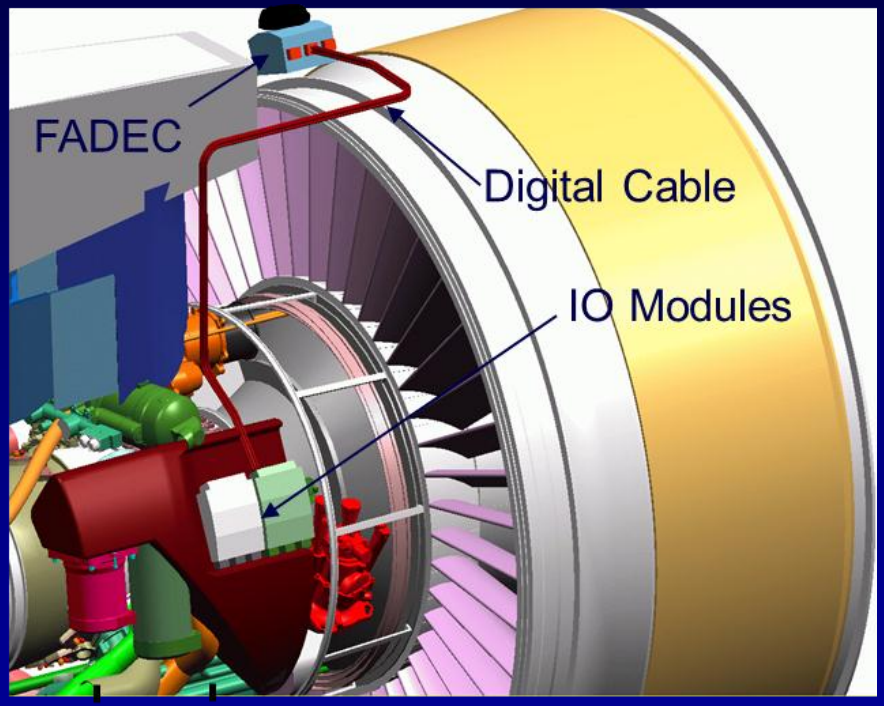
Smart nodes in hot section

Communications protocol(s)

Multiple protocols in play

EMI/HIRF/Lightning susceptibility

Software validation (DO-178C)



HARSH ENGINE ENVIRONMENTS

Continually Increasing Temperatures The Norm

Ambient temperatures increasing

Based On Location

Cooling capabilities decreasing

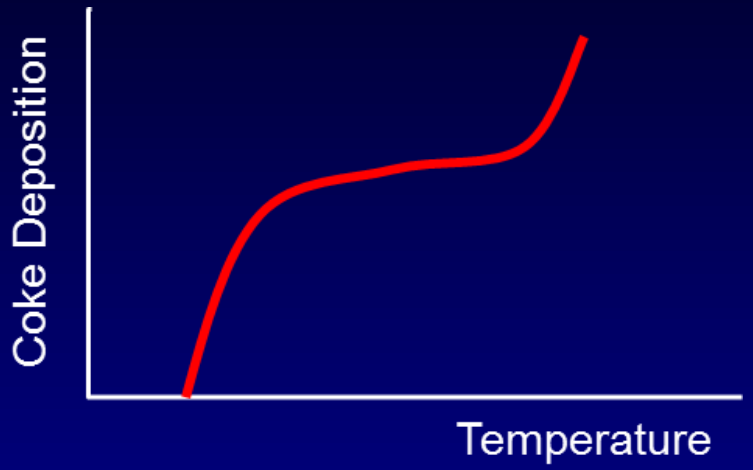
Hotter fuel, hotter air

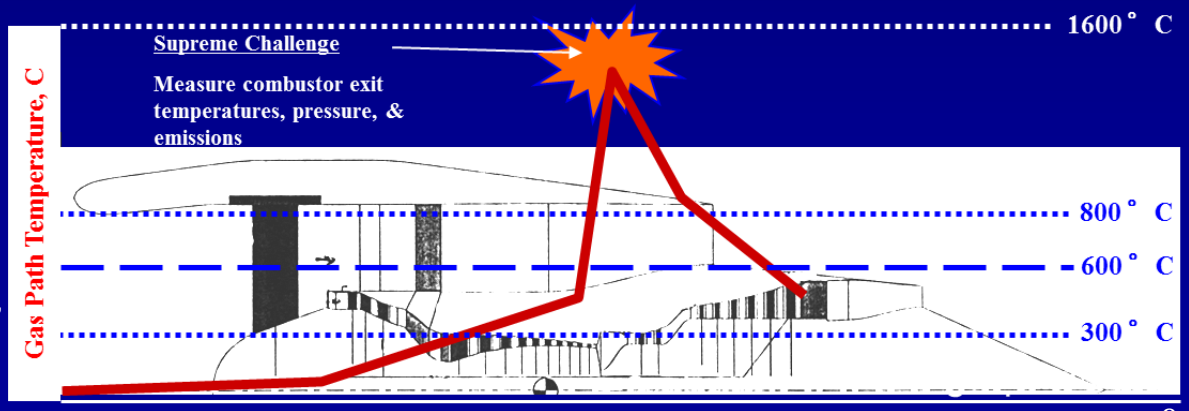
Less real estate for mounting

Core mounting vs. fan mounting

Robust electronics limited

DECWG research ongoing





Courtesy: NASA

45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit,
4 August 2009, Denver, Colorado
Transition in Gas Turbine Engine Control System Architecture:
Modular, Distributed, Embedded

APPROACH TO HARSHER ENVIRONMENTS

High(er) Temperature Electronics

Limited performance

Lack of high-end processing/memory

Limited life

Lifing investigation ongoing

Limited supply base

Niche market

Limited affordability

Significantly higher costs

Limited support

Circuit boards, solders, masks…

DECWG research

POTENTIAL FUTURE DIRECTIONS

Distributed control architecture

- Off-engine component – Environmentally benign
- On-engine component – Local loop closure, smart sensing

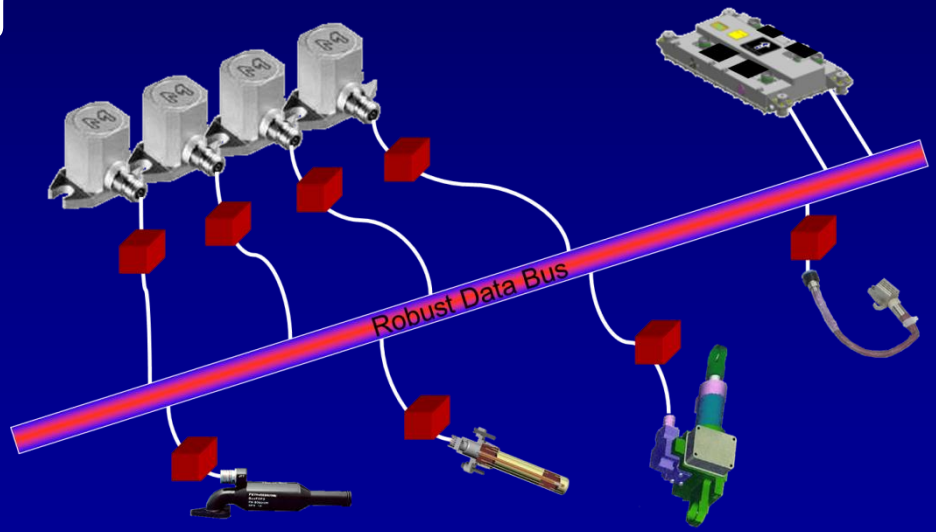
Multi-spectral / Multi-functional sensing

Controls integration w/ PHM

Engine / Airframe integrated networks

Engine / Flight control integration

Environmental control for electronics
or high(er) temperature electronics



THE FUTURE IS NOW

Control Systems Lead The Way